SANDAKANIA 3 (1993): 1-9

Four new species of *Engelhardia* (*Juglandaceae*) from Borneo

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Summary. Four new species of *Engelhardia* are described from Borneo and a key to all species present in Borneo is provided.

The genus *Engelhardia* was established in 1825 and is typified by *E. spicata* Leschen. ex Bl. from Java. Until recently, eight species have been recognised in the genus, three in America, the other five from Indo-China through Malaysia to New Guinea. In 1960 Jacobs revised the five Asian species in Flora Malesiana and Cockburn (1976) and Ashton (1988) have since published accounts of the genus in Sabah and Sarawak, respectively. The five Asian species are *E. apoensis* Elmer ex Nagel, *E. rigida* Bl., *E. roxburghiana* Wallich, *E. serrata* Bl. and *E. spicata* Leschen. ex Bl. These five species all occur in Borneo and are highly localised and, thus, rare species mostly occurring at upper elevations on mountains.

With a new revision of the genus in Borneo for the Tree Flora of Sabah and Sarawak, four new species have been distinguished, three occurring in Sabah and one occurring in Sarawak. The distinguishing characteristics of the four new species, notes on their ecology and distribution, and a key to all species in Borneo are provided.

Distinction of the species

Two keys are presented, the first using only vegetative characters, and the other using fruit characters, as these provide good differences. Flowering material is not available for all the taxa. Table 1 lists differences in the fruit characters for the Bornean species, and Fig. 1 shows some important fruit characters.

Table 1. A comparison of some fruit and fruit-bract characters in the Bornean species of *Engelhardia.*

Species	Nut size (mm)	Nut shape	Hairs on nut	Size of abaxial lobe of bract (mm)	Size of lateral lobes of bract (mm)	Form of adaxial lobe of bract	Form & position of perianth
E. apoensis	6-14 x 5-6	ovoid	long, soft	55-75 x 12-15	20-35 x 8	entire to shallowly 4-lobed	inconspicuous tiny lobes, adnate to style
E. danumensis	3 x 3	globose	short	19-30 x 6-9	8-11 x 3-4	shallowly cleft in middle	ovate lobes, apex of nut
E. kinabaluensis	2-3 x 3-4	transversely ellipsoid	short	20-24 x 5-6	8-12 x 2-3	deeply cleft in middle	linear lobes, apex of nut
E. mendalomensis	3-4 x 4-5	transversely ellipsoid	short	21-50 x 8-10	11-18 x 4-6	subtruncate (margin sometimes wavy)	ovate lobes, apex of nut
E. mersingensis	3 x 4-6	transversely ellipsoid	short	20-31 x 7-10	9-16 X 4-6	(nil)	linear lobes, apex of nut
E. rigida	3.5 x 4	globose	long, soft	20-60 x 3-8	12-14 x 3-4	orbicular	ovate lobes, apex of nut
E. roxburghiana	4-5 x 4-5	globose	(nil)	28-55 x 5-8	21 x 5-6	(nil)	ovate lobes, apex of nut
E. serrata	3 x 3	globose	long, stiff	16-40 x 6-11	6-12 x 3-6	frilled to shallowly 2-3-lobed	ovate lobes, apex of nut
E. spicata	3-6 x 3-8	globose to transversely ellipsoid	long, soft	20-60 x 7-15	20-25 x 5-8	frilled to shallowly 4-5-lobed	inconspicuous tiny lobes, adnate to style

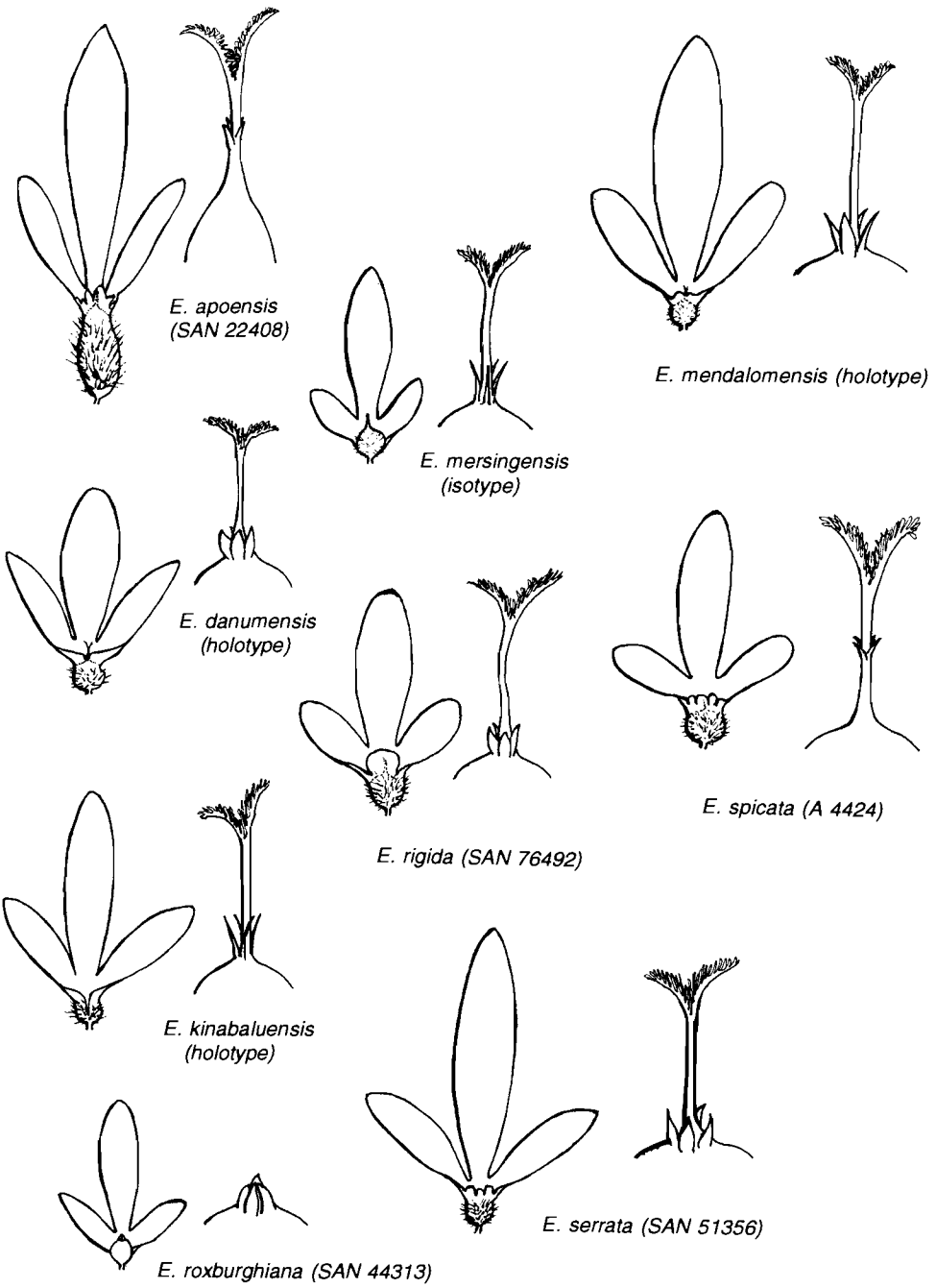

Fig.1. Fruit structures in the different species of *Engelhardia*. For each species, the drawing on the left shows the outline of the fruit and the form of the adaxial (frontal) lobe of the bract (if present), the drawing on the right shows the apex of the nut with the style (if visible) and the perianth lobes.

KEY TO *ENGELHARDIA* SPECIES
(based on vegetative characters)

1a. Leaflet margins distinctly toothed, at least in the upper half.

2a. Distal leaflets often twice as large as the lower ones; leaflet bases acute or wedge-shaped; tertiary veins and areoles mostly invisible on upper surface in dried specimens; stalk nil to 1 mm, rarely more ..... *E. serrata*

2b. Distal leaflets sometimes larger than lower ones but not up to twice as large; leaflet bases rounded to subcordate; tertiary veins and areoles distinct on upper surface in dried specimens; stalk longer, to 4 mm ..... *E. apoensis*

1b. Leaflet margins entire or wavy, not toothed.

3a. Leaflets coriaceous, elliptic-obovate (or if lanceolate-falcate then with nerves impressed on the upper side), and not hairy on the lower side.

4a. Leaflet tertiary venation coarse, the areolation strongly prominent under 10X magnification ..... *E. kinabaluensis*, sp. nov.

4b. Leaflet tertiary venation finer, the areolation only faintly visible under 10X magnification.

5a. Shoot apices and leaf rachises brown scurfy hairy ..... *E. rigida*

5b. Shoot apices and leaf rachises not scurfy hairy .... *E. mersingensis*, sp. nov.

3b. Leaflets chartaceous, or lanceolate-falcate, or with hairy veins on the lower side (the nerves not impressed on the upper side).

6a. Leaflets not decreasing markedly in size from apex to base of leaf rachis; veins on lower side hairy ..... *E. spicata*

6b. Leaflets decreasing in size by one third to half from apex of leaf rachis; veins on lower side minutely scaly to subglabrous or apparently glabrous.

7a. Leaflets elliptic, papery, base slightly unequal, margin not thickened; stalk almost nil or only to 1 mm long ..... *E. danumensis*, sp. nov.

7b. Leaflets ovate to lanceolate or falcate, leathery, base very unequal, margin thickened; stalk 1-10 mm long.

8a. Leaflets to 11 cm long, usually 4-5 pairs per leaf; stalk 1-4 mm long ..... *E. mendalomensis*, sp. nov.

8b. Leaflets usually larger, to 16 cm long, usually 2-3 pairs per leaf; stalk longer, to 10 mm ..... *E. roxburghiana*

KEY TO *ENGELHARDIA* SPECIES
(based on fruit characters)

1a. Nut 6-14 mm long with a conspicuously narrowed apex ..... *E. apoensis*

1b. Nut shorter, to 6 mm long, apex rounded.

2a. Adaxial lobe of bract not developed, the nut fully exposed.

3a. Nut stalk 4-8 mm long. Nut covered with scales only. Perianth lobes broadly ovate ..... *E. roxburghiana*

3b. Nut stalk shorter, to 3 mm long. Nut hairy. Perianth lobes linear ..... *E. mersingensis*, sp. nov.

2b. Adaxial lobe of bract truncate to lobe-like, hiding most of the nut.

4a. Perianth of inconspicuous tiny lobes adnate to the style ..... *E. spicata*

4b. Perianth of ovate to linear lobes at the apex of the nut.

5a. Nut set with stiff, loose, irritant long hairs ..... *E. serrata*

5b. Nut indumentum not so.

6a. Adaxial lobe of bract cleft in the middle.

7a. Adaxial lobe of bract only shallowly cleft. Perianth lobes broadly ovate ..... *E. danumensis*, sp. nov.

7b. Adaxial lobe of bract deeply cleft to the base. Perianth lobes linear ..... *E. kinabaluensis*, sp. nov.

6b. Adaxial lobe of bract not cleft in the middle, either orbicular or subtruncate (margin sometimes wavy).

8a. Adaxial lobe of bract orbicular ..... *E. rigida*

8b. Adaxial lobe of bract subtruncate, the margin sometimes wavy ..... *E. mendalomensis*, sp. nov.

The new species

Engelhardia danumensis *Campbell*, **sp. nov.** *species E. rigidae Bl. affinis sed foliolis in sicco nigrescentibus, quae crassitiem tenuiter papyraceam, inferioris dimidialis parte magnitudinis diminutae, habent et squamis sed nunquam pilis induta sunt, nuce et squamis pilisque vestita differt. Typus: Cockburn SAN 85066, Sabah, Lahad Datu, Ulu Segama Forest Reserve, Ulu Sungai Danum (holotypus SAN; isotypi A, BO, FHO, K, KEP, L, SAR, SING).*

Tree, to 33 m tall and 58 cm diameter. Buttresses thin, plank-like, 1 m tall and 2 m long. Bark surface dark chocolate-brown, fissured and flaking by small rectangular flakes; living bark orange-brown, 1.2 cm thick, fibrous, cut wood and bark smelling like coconut water. Wood white, hard. Twigs and leaves set with golden scales but with no hairs present. Leaf rachis 4-10 cm long, 2.8-4.2 cm to first leaflet, blackish, not thickened at base, scales occasional; leaflets 2-3 pairs, alternate to subopposite; leaflets elliptic, 2.4-7 x 1.5-3.5 cm, decreasing to half the size towards base, lamina below drying dark brown to blackish, texture thin, papery, above glabrous, below with occasional to scattered scales all over; base acute to wedge-shaped, subequal; apex acute to shortly acuminate, acumen to 5 mm long; margin entire, undulate, marginal nerve not thickened; midrib on both sides drying darker than lamina; tuft domatia occasionally found in the nerve axils with the midrib; nerves 8-12 pairs, nerves on both sides raised, conspicuous, drying the same colour as the lamina on the upper side, slightly darker than the lamina on the lower side; veins net-like, obscure on both sides, drying the same colour as lamina, areoles obscure; sessile to stalked 1 mm long, furrowed above, glabrous or with scattered scales. Inflorescences axillary, flowers not known; fruiting catkins 14-18 cm long including peduncle, rachis with scales and hairs. Fruits sessile to 1-mm-stalked, nut globose, 3 x 3 mm, rachis slender, angular, drying blackish, set with golden scales and short golden hairs; bract abaxial wing 19-30 x 6-9 mm, lateral wings 8-11 x 3-4 mm, set with scales and a few hairs, adaxial lobe shallowly cleft in the middle; perianth lobes ovate.

Known only from the type collection.

Ecology: The tree was found on a steep hill with rocky outcrops at 500 m altitude. Vegetatively it approaches *E. rigida* but the leaflets dry almost blackish, have a thin and papery texture, the lower leaflets decrease in size by half, and the lamina is set with scales but never hairs. Also, the nut in this species differs in being set with both scales and short hairs.

Engelhardia kinabaluensis *Campbell*, **sp. nov.** *species E. rigidae Bl. accedens sed foliolis crassis coriaceisque, lamina squamis sed nunquam pilis induta, nuce etiam squamis sed brevis pilis vestita differt. Typus: Aban Gibot SAN 66824, Sabah, Ranau, Mamut copper mining area (holotypus SAN).*

Tree, to 24 m tall and 35 cm diameter. Bark surface grey to blackish, rather scaly to fissured; living bark yellow to pale white, exudate yellow. Wood cream. Twigs, leaves and inflorescence set with gold scales but without hairs. Leaf rachis 3.7-8 cm long, 1.5-3.5 cm to first leaflet, thickened at base, 1-4 mm thick, black, with sparse scales; leaflets 2-3 pairs, subopposite to opposite, elliptic to obovate in outline, 1.5-6.2 x 0.7-2.8 cm, drying grey-brown to orange-brown, thickly leathery, midrib and nerve beginnings impressed, upper side glabrous, lower side glabrous to sparsely scaly, base very unequal, apex acute to shortly acuminate (acumen to 2 mm long), margin entire and wavy with a thickened marginal nerve, tuft domatia absent to rare in the nerve axils with midrib, nerves 5-7 pairs and flat to occasionally impressed on the upper side, often obscure, areoles visible and strongly prominent under 10x magnification; stalk 2-3 mm, furrowed, glabrous or with occasional scales. Inflorescences axillary, flowers not known; fruiting catkins 7-10 cm long, rachis slender, angular, drying blackish, set with scales and hairs. Fruit with a stalk 1-2 mm long; nut transversely ellipsoid, 2-3 x 3-4 mm, set with gold scales and short, golden hairs, surrounded by the bract; bract abaxial wing 20-24 x 5-6 mm, lateral wings 8-12 x 2-3 mm, occasionally scaly, hairs absent, adaxial lobe deeply cleft in the middle; perianth lobes linear.

SPECIMENS EXAMINED - BORNEO. SABAH: Gunung Kinabalu, Mesilau Area, Kundasang, Madani & Ong SAN 111603 (SAN); Ranau, Mamut Copper Mine, Aban SAN 66824 (holotype SAN), Cockburn SAN 74274 (SAN).

Ecology: Found in lowland and montane forest from 200 to 1500 m altitude. Vegetatively it approaches *E. rigida* but the leaflets with their thickly leathery texture, the cover of scales on the leaflets and nut, and the lack of hairs on the leaflets and nut distinguish it from that species.

Engelhardia mendalomensis *Campbell*, **sp. nov.** *species ad E. roxburghianam Wall. characteribus vegetativis accedens, sed a qua foliolis usque ad quadri-quinquejugis, in sicco atrobrunneis vel nigrescentibus, nervarum paribus paucioribus, minus dense squamis indutis, nuce sessili vel breviter (usque 1 mm) pedicellata et squamis et pilis induta differt. Typus: Fidilis Krispinus SAN 116714, Sabah, Tenom, Mendalom Forest Reserve (holotypus SAN).*

Tree, to 32 m tall and 80 cm diameter. Buttresses up to 3 m high, 4 m long and 10 cm thick. Bark surface pale brown-grey; living bark pale yellow to orange-brown. Wood cream-white to yellowish. Twigs and leaves set with golden scales, without hairs. Leaf rachis 6-14 cm long, 2.2-6 cm to first leaflet, blackish, thickened at base, 1-4 mm, scales scattered with rarely a few hairs present; leaflets (3-)4-5 pairs, sub-opposite to opposite; leaflets ovate to lanceolate, 4-11 x 2-4 cm, often decreasing markedly towards base to

about two-thirds to half the size, lamina on lower side drying dark brown to blackish, texture thinly leathery, with occasional scales but no hairs all over on both sides; base acute or very occasionally round, very unequal; apex acute to long acuminate, acumen to 10 mm long; margin entire, slightly wavy, with thickened marginal nerve; midrib on both sides drying blackish; occasional to no tuft domatia present in nerve axils with midrib; main nerves 7-11 pairs, nerves on upper side raised but rather obscure, drying the same colour as the lamina, glabrous, nerves on lower side raised, conspicuous, drying darker than lamina; veins net-like, obscure on the upper side, glabrous, drying the same colour as lamina, areoles on both sides obscure; stalk 1-4 mm long, furrowed above, scales scattered. Inflorescences axillary, flowers not known; fruiting catkins 13-30 cm long including peduncle, rachis quite stout, angular, drying blackish, set with scales and hairs. Fruits sessile to 1-mm-stalked, nut transversely ellipsoid to globose, 3-4 x 4-5 mm, set with golden scales and scattered short golden hairs; bract abaxial wing 21-50 x 8-10 mm, lateral wings 11-18 x 4-6 mm, set with scales and hairs, adaxial lobe subtruncate (the margin sometimes wavy); perianth lobes ovate.

SPECIMENS EXAMINED - BORNEO. SABAH: Tenom, Mendalom Forest Reserve, Fidilis Krispinus SAN 116714 (holotype SAN). **NEW GUINEA**: Henty & Forman NGF 42626 (L); Jackson & Womersley 4163 (L); Moll BW9603 (L), 9623 (L); Carr 12885 (L); Darbyshire & Hoogland 8310 (L); Schodde 3060 (L); Hasker BW1043 (L).

Ecology: Primary forest from sea-level to 550 m altitude. Vegetatively it approaches *E. roxburghiana* but differs in having four to five pairs of leaflets drying dark brown to blackish, with fewer pairs of nerves, and being less densely set with scales. Also, a sessile to 1-mm-pedicellate nut set with both hairs and scales distinguish it from that species.

Engelhardia mersingensis *Campbell,* **sp. nov.** *species E. rigidae Bl. accedens sed foliolis majoribus, nervarum paribus paucioribus, squamis sed nunquam pilis vestitis, nuce sessili usque breviter (ad 2 mm) pedicellata, squamis sed brevis pilis vestita differt. Typus: Ashton S. 16724, Sarawak, Bukit Mersing, Ulu Anap (holotypus SAR; isotypi A, BO, K, KEP, L, MEL, SAN, SING).*

Tree, to 30 m tall and 68 cm diameter. Buttresses tall, sinuate and branching. Bark surface pale orange-brown, thin, powdery, flaked. Twigs, leaves and inflorescences set with golden and orange scales, but without hairs. Leaf rachis 4.5-14 cm long, 2.5-4.5 cm to first leaflet, thickened at base, 1-3 mm thick, stout, black, with sparse to scattered scales, not hairy; leaflets 3-4 pairs, alternate to opposite, elliptic to obovate, 4.5-11 x 2.5-4.8 cm, drying orange-brown to blackish, thinly leathery, upper side glabrous, lower side sparsely to scattered scaly; base subequal to very unequal, apex acute to acuminate (acumen to 9 mm long), margin entire and slightly wavy with a thickened marginal nerve, tuft domatia occasionally found in nerve axils with midrib, nerves 7-12 pairs and impressed or keeled on the upper side, areoles only slightly visible under 10x magnification; stalk 1-2 mm long, furrowed, with scattered scales. Inflorescences terminal, occasionally axillary, flowers not known; fruiting catkins 9.5-20 cm long, rachis quite stout, angular, drying dark

brown or blackish, set with scales and hairs. Fruit sessile to 2-mm-stalked; nut transversely ellipsoid, 3 x 4-6 mm, with scales and a few short hairs present; bract abaxial wing 20-31 x 7-10 mm, lateral wings 9-16 x 4-6 mm, glabrous to scaly, without hairs, adaxial lobe not developed; perianth lobes linear.

SPECIMENS EXAMINED - BORNEO. SARAWAK: 3rd Division, Bukit Mersing, Ulu Anap, Ashton S. 16724 (holotype SAR, isotypes A, BO, K, KEP, L, MEL, SAN, SING); Sibat S. 21946 (A, BO, K, KEP, L, MEL, P, SAN, SING); Sibat S. 21883 (A, BO, K, KEP, L, MEL, SAN, SING). **EAST KALIMANTAN**: Balikpapan District, Gunung Beratus, Kostermans 7406 (BO).

Ecology: Found at 600-1000 m in primary submontane forest on sandstone and basaltic soils. Vegetatively this species approaches *E. rigida* but the larger leaflets, fewer pairs of nerves, set with scales but not hairs and a sessile to 2-mm-pedicellate nut with scales and short hairs distinguish it from that species.

ACKNOWLEDGEMENTS

I thank the Malaysian herbaria of Sandakan, Kuching and Kepong, the Royal Botanic Gardens, Kew, and the Rijksherbarium, Leiden, for permission to borrow and consult their material.

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